REMARKS/ARGUMENTS

Claims 1-3 are canceled herein without prejudice or disclaimer to the subject matter.

Claims 4-6 are amended for formal reasons, in particular to reorder the elements recited in claim 4.

Claim 4 also is amended to recite a worm gear. This is supported by the disclosure, for example as illustrated in Figure 5, wherein worm gear 12A is shown.

Claim 4 is amended to refer to "supporting units" rather than "end part holding means", and a "distortion prevention unit" instead of "center supporting means". Claim 5 similarly is amended to refer to an "engagement assistor" instead of "urging means". Applicants respectfully submit that referring to previously disclosed elements by different names does not constitute the addition of new matter.

New claims 7-10 are added to recite that the ends of the worm shaft are supported without play. This is supported by the disclosure, for example in paragraph 19.

New claim 11 is added to recite that the worm shaft is joined with the electric motor, as formerly recited in claim 4.

No new matter has been added. Claims 4-11 are pending in the application.

Applicants respectfully request that the preliminary amendment described herein be entered into the record prior to calculation of the filing fee and prior to examination and consideration of the above-identified application.

If a telephone conference would be helpful in resolving any issues concerning this communication, please contact Applicants' primary attorney-of-record, Curtis B. Hamre (Reg. No 29,165) at (612) 336-4722.

Respectfully submitted,

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ELECTRIC MOTOR ASSIST TYPE POWER STEERING APPARATUS

BACKGROUND OF THE INVENTION

1. FIELD OF THE INVENTION

The present invention relates to an electric motor assist type power steering apparatus. More specifically, the present invention relates to an electric-motor-controlled power steering apparatus, which ~~assists~~ reduces the steering effort of a driver by ~~making the~~ applying power (steering torque) generated by an electric motor ~~power-act on~~ to a steering system ~~directly~~.

2. PRIOR ART

An electric motor assist type power steering apparatus (hereinafter defined as ~~an electric~~ "power steering apparatus") ~~assists the~~ supplies an assistant steering force ~~of~~ to a steering system in order to assist a driver ~~by making use of the driving force of an electric motor directly~~ in turning a steering wheel. ~~A vehicle, on which an electric~~ Vehicles equipped with power steering apparatus ~~is mounted, is widely spreads, and according to the electric poser steering apparatus, since a movement of the steering becomes light, a driver operates the steering without strong force~~ are in widespread use. In such vehicles, since smooth turning of the steering wheel is enabled by the power steering apparatus, the driver can turn the steering wheel with ease.

As an example of ~~the electric~~ these kinds of power steering apparatus, a pinion assist type electric power steering apparatus, in which a worm shaft and a worm wheel are used ~~as the means for transmitting the driving~~ in order to transmit an assistant steering force ~~of~~ generated by an electric motor to a steering shaft, is known. The ~~electric~~ power steering apparatus, disclosed in the Japanese patent unexamined patent publication H11-43062, is one example thereof.

8 In this ~~electric~~ power steering apparatus, as shown in FIG. 8, an electric motor 51 ~~for adding~~ , which is used to provide an ~~assist~~ assistant steering force to a steering shaft, ~~which is rotated by the operation of the steering,~~ is provided. When the steering wheel is rotated in order to turn the steering shaft, the electric motor 51 supplies the assistant steering force to help rotate the steering shaft. The ~~worm shaft 52~~ electric motor 51 is connected to ~~the electric motor 51~~ a worm shaft 52. A ~~pinion shaft 53 is joined with the steering shaft. The worm wheel 54, which is engaged with a~~ worm gear 52A of the worm shaft 52 is engaged with a worm wheel 54, ~~is fixed to a pinion shaft 53 so that it will be in the coaxial location~~ which is coaxially arranged with respect to ~~the~~ a pinion shaft 53.

9 ~~Both end parts~~ Ends 52B and 52C of the worm shaft 52 are ~~held~~ supported by ball bearings 55 and 56~~, respectively~~. The ~~assist~~ assistant steering force ~~brought~~ generated by the electric motor 51 is ~~add~~ transferred to the pinion shaft 53 through the worm gear 52A and the worm wheel 54, which are engaged ~~together~~ with each other. ~~By adding this assist steering force, the steering force required for steering operation of a driver is decreased.~~ Thereby, the effort that must be exerted by a driver to turn the steering wheel is alleviated by the assistant steering force.

10 In the ~~electric~~ power steering apparatus 50 disclosed in the above described Japanese unexamined patent application, however, ~~both end parts~~ ends 52B and 52C of the worm shaft 52 are ~~rotatably held~~ only supported by ~~the~~ ball ~~bearing~~ bearings 55 and 56, with the occurrence of backlash.

11 ~~Since~~ Therein, since the flexural rigidity (also referred to as flexural resistance, the capacity of an object to resist flexing when stress is applied to thereto) of the worm shaft 52 is ~~not so high~~ relatively low, the ~~flexure of the~~ worm shaft 52 tends to be ~~arisen~~ easily deformed by the load applied to the worm shaft 52. ~~When~~ Therefore, when the steering wheel is turned back in the other way ~~while turning in the one direction~~, since

the steering torque sensed by ~~the~~ a torque sensor (not shown) decreases, the electric motor 51 is controlled so ~~that the assist~~ as to provide a decreased assistant steering force ~~will be decreased~~.

12 ~~In this case,~~ It is desirable to enable the steering ~~must~~ wheel to be turned back ~~with~~ smoothly, by rotating the electric motor 51 through the worm wheel 54 and worm shaft 52. ~~If the flexure is arising on~~ But, if the worm shaft 52 has flexed, ~~however,~~ since the assistant steering force has decreased, the bending moment ~~affected to the rotation shaft of the worm gear 52A is decreased by the decreasing of the assist steering force brought by the electric motor 51, the~~ for affecting the worm shaft 52 decreases. When a restoring force is applied to the worm shaft 52, restorative deformation ~~is arisen for correcting the flexure~~ of the worm shaft 52 occurs.

13 Since ~~this~~ the restorative deformation ~~acts as an undesirable force and inhibits~~ disturbs the rotation of the worm gear 52A, the ~~rotation~~ assistant steering force from the ~~worm wheel 54~~ electric motor 51 is not ~~smoothly~~ transmitted to the ~~electric motor 51~~ worm wheel 54. Thus, the ~~mismatch on the suitable relationship among~~ proper relationships between the torque sensor ~~(not shown)~~, the control unit, and the electric motor 51 ~~is arisen~~ are impaired. ~~When~~ These relationships are further impaired due to the moment of the inertia ~~is add thereto, mismatch is further promoted~~ of the electric motor 51. ~~Then, the turning back~~ Thus, the operational ability of the steering wheel is ~~disturbed and thus the response of the steering~~ becomes worse.

14 In the electric power steering apparatus 50, moreover, ~~the~~ an excessive gap or clearance ~~which exceeds a predetermined clearance value may be arose~~ may develop between the worm gear 52A and the worm wheel 54 as ~~the occurrence of the flexure of~~ the worm shaft 52 flexes. When such clearance arises, the ~~dispensable~~ backlash between the worm gear 52A and the worm wheel 54 ~~becomes larger~~ can become large.

Thus, the ~~assist~~ assistant steering force ~~brought~~ generated by the electric motor 51 cannot be ~~transmitted~~ transferred completely to the steering shaft ~~completely~~.

15 These disadvantages caused by the ~~flexure~~ distortion of the worm shaft 52 ~~will be remarkable~~ are especially pronounced when the ~~assist~~ assistant steering force ~~brought~~ generated by the electric motor 51 ~~becomes~~ is large.

16 SUMMARY OF THE INVENTION

17 ~~This is therefore, the~~ The present invention ~~aim at providing the~~ relates to an electric ~~motor assist type~~ power steering apparatus, ~~preferably the pinion assist type electric power steering apparatus, which can prevent the aggravation of the feeling of the steering by preventing the flexure of the worm shaft, and which can transmit the assist~~ that transmits a steering force ~~of the electric motor to the steering shaft completely~~ to be added to the steering wheel, in compliance with the steering force exerted by the driver.

18 ~~For attaining these problems, there is provided an~~ This electric power steering apparatus ~~comprising;~~ includes an electric motor for ~~adding~~ generating the ~~assist~~ assistant steering force ~~to the steering system, a controller which drives said electric motor, a rack shaft which steers a steered wheel by displacing along the axial direction thereof, a pinion shaft which is engaged with said rack shaft through the rack and pinion mechanism~~, a worm shaft ~~which is~~ engaged with the electric motor so as to be rotated ~~by the electric motor, and~~ thereby, a worm gear disposed on the worm shaft and engaged therewith so as to rotate therewith, a worm wheel ~~which is~~ engaged with ~~said~~ the worm gear on the worm shaft so as to be rotated by the worm gear, and ~~is integrally arranged with the~~ a pinion shaft~~, one end part of the worm shaft is joined with the electric motor~~ engaged with the worm wheel so as to rotate therewith. The present invention also includes a rack shaft engaged with at least one steered wheel so as to

displace the steered wheel in an axial direction of the rack shaft, and ~~holding means, which holds one end part and another end part~~ first and second supporting units supporting the first and second ends of the worm shaft ~~on allowing the rotation thereof, is further arranged~~. The present invention further includes a distortion prevention unit engaged with the worm shaft at the middle thereof.

19 In the electric power steering apparatus according to the present invention, ~~one end part and another end part of the worm shaft are held~~ both ends of the worm shaft are supported by the supporting units without play. ~~The worm shaft, in the conventional manner, is held with play, thus the flexural rigidity is not so high and the flexure of the worm shaft is easily arisen. On the other hand, the worm shaft, in the present invention, is held without play, thus~~ Thus, the worm shaft can be ~~held~~ supported with high flexural rigidity.

20 Accordingly, ~~by preventing the occurrence of the flexure~~ since distortion of the worm shaft is avoided, ~~not only the occurrence of the mismatch caused by the flexure of the worm shaft at the time of turning back of the steering but also the occurrence of the aggravation of the steering feeling are prevented. Thus, the certain transmission of~~ the steering force ~~brought~~ generated by the electric motor may be reliably transferred to the pinion shaft ~~can be achieved~~. Difficulties with the operational ability of the steering wheel thus may be avoided.

21 In the electric power steering apparatus, preferably, ~~said holding means~~ each of the supporting units is composed of ~~plural~~ ball bearings ~~which hold one end part~~ for supporting their respective ends of the worm shaft~~, and plural ball bearings which hold the another end part of the worm shaft~~.

22 According to this electric power steering apparatus, both ~~end parts~~ ends of the worm shaft are ~~held~~ supported without play ~~by plural of~~ using ball bearings. Thus, the ~~holding of the~~ worm shaft ~~can be carried out on keeping the rotating condition at the~~

~~both ends of the worm shaft into the smooth condition~~ can be rotated while being well supported. ~~And also the holding of the worm shaft can be carried out using ball~~ Because ball bearings~~, which~~ are general-purpose parts, this may be accomplished without using ~~the specific~~ specialized parts. ~~Therefore, the contribution to~~ Consequently, a cost reduction may be attained.

23 ~~In~~ Alternatively, in the electric power steering apparatus, preferably, ~~said holding means is composed of plural~~ the supporting units include ball bearings which ~~hold~~ support the ~~one~~ first end ~~part~~ of the worm shaft, and a needle bearing which ~~holds another~~ supports the second end ~~par~~ of the worm shaft.

24 According to this electric power steering apparatus, ~~one~~ the first end ~~part side~~ of the worm shaft that is joined with the electric motor is ~~held~~ supported by ~~the plural of~~ ball bearings. Since ~~one~~ the first end ~~part~~ of the worm shaft is joined with the electric motor, flexural rigidity in the ~~one~~ first end ~~part~~ of the worm shaft is comparatively high. However, ~~and that of in the another~~ if left unsupported, the flexural rigidity of the other end ~~part~~ becomes relatively low ~~a little~~.

25 In the present electric power steering apparatus, therefore, ~~another~~ the second end ~~part~~ of the worm shaft is ~~held~~ supported by a needle bearing, without play. When the worm shaft is ~~held~~ supported by the needle bearing without play, ~~since the flexural resistance of the worm shaft in the diameter direction is higher than the worm shaft held by the plural of ball bearings,~~ the flexural rigidity along the worm gear as a whole may be higher. ~~Thus, the occurrence of the flexure of the worm shaft is thus prevented, and also the occurrence of the feeling gap between in the case the steering is turned back in the anticlockwise direction and in the case the steering is turned back in the clockwise direction can be decreased. Thus, not only the prevention of the aggravation of steering feeling but also the certain transmission of the steering force brought by the electric~~

~~motor 7 to the pinion shaft 3 are achieved.~~ Difficulties with the operational ability of the steering wheel thus may be avoided.

26 ~~In the present invention, furthermore, there is provided~~ Furthermore, the present invention relates to an electric power steering apparatus ~~comprising;~~ including an electric motor ~~for adding the assist~~ generating an assistant steering force to be added to the steering system, ~~a controller which drives said electric motor, a rack shaft which steers a steered wheel by displacing along the axial direction thereof, a pinion shaft which is engaged with said rack shaft through the rack-and-pinion mechanism,~~ a worm shaft ~~which is~~ engaged with the electric motor so as to be rotated ~~by the electric motor~~ thereby, a worm gear disposed on the worm shaft and engaged with the worm shaft so as to rotate therewith, a worm wheel ~~which is~~ engaged with ~~said~~ the worm gear on the worm shaft so as to be rotated by the worm gear, ~~and is integrally arranged with the~~ pinion shaft engaged with the worm wheel so as to rotate therewith, and a rack shaft engaged with at least one steered wheel so as to displace the steered wheel along the axial direction of the rack shaft. ~~, end part holding means which holds the one end part~~ First and second supporting units support the first and second ends of the worm shaft ~~on~~ while allowing ~~the~~ rotation of the worm shaft, and ~~center supporting means which holds the center part in the longitudinal direction~~ a distortion prevention unit is engaged with the middle of the worm shaft ~~on~~ while allowing ~~the~~ rotation of the worm shaft~~, wherein one end part of said worm shaft is joined with the electric motor~~.

27 The electric motor, worm wheel, and supporting units may be referred to collectively as a torque transmission unit.

28 According to this electric power steering apparatus, ~~about the center part~~ the middle in the longitudinal direction of the worm shaft is supported ~~on~~ by the distortion prevention unit while allowing ~~the~~ rotation of the worm shaft. Thus, the worm shaft can be made ~~into the rotatable condition~~ to rotate, and ~~the occurrence of the flexure~~

distortion of the worm shaft can be prevented. ~~This is therefore~~ Thus, ~~the aggravation of the feeling of the steering is prevented~~ difficulties with the operational ability of the steering wheel thus may be avoided, and the steering force ~~brought~~ generated by the electric motor can be transmitted reliably to the pinion shaft ~~certainly~~. ~~According to the center supporting means~~ With the use of a distortion prevention unit, the ~~worm shaft is held without arranging the holding means~~ supporting unit at ~~one~~ the first end ~~part~~ of the worm shaft may be omitted, and the assembling efficiency of the apparatus as a whole is improved.

29 In the electric power steering apparatus, ~~preferably, said center supporting means has urging means~~ it is preferable that the distortion prevention unit includes an engagement assistor, which ~~gives the urging force towards the engaging part between~~ pushes the worm shaft ~~and~~ into engagement against the worm wheel ~~from the opposite direction with respect to the engaging part~~.

30 According to the present invention, ~~the urging means which urges~~ since the engagement assistor pushes the worm shaft ~~to the engaging part side~~ into engagement with ~~respect to~~ the worm wheel ~~is arranged. Since the flexure~~ , distortion of the worm shaft is prevented, and the worm shaft is pressed to the worm wheel with sufficient force~~,~~ so that the clearance between the worm shaft and the worm wheel is maintained within the predetermined range. ~~Thus, the~~ The occurrence of the unpleasant backlash between the worm gear and the worm wheel can be prevented, and the ~~certain transmission of the~~ rotation force of the worm shaft can be reliably transmitted to the worm wheel ~~can be achieved~~.

31 In the electric power steering apparatus, ~~preferably, said center supporting means has~~ it is preferable that the engagement assistor includes a first roller, ~~and~~ a second roller ~~which are touched with~~ adjacent to the first roller, and a spring that pushes

the first and second rollers against the worm shaft ~~and press the worm shaft toward the engaging part between the worm shaft and the worm wheel~~.

32 ~~According to the present invention, the~~ In this electric power steering apparatus, the worm shaft is pushed against the worm wheel with the worm shaft central to the first roller and the second roller~~, which are fitted with the worm shaft, is applied to the engaging part between the worm shaft and the worm wheel~~. Thus, ~~the~~ displacement ~~in the ups-and-downs directions~~ of the worm shaft in an up-and-down direction is restricted, and the engagement assistor engages the worm shaft is ~~applied to the engaging part between the worm shaft and~~ with the worm wheel. Since ~~the roller is~~ rollers are used, friction is low, and the ~~supporting mechanism with slightest fiction can be obtained~~ rotation of the worm shaft is not prevented.

33 BRIEF DESCRIPTION OF THE DRAWINGS

34 FIG. 1 is a ~~whole~~ block diagram showing the whole of the electric power steering apparatus according to the first preferred embodiment of the present invention.

35 FIG. 2 is a ~~plan~~ plane view of ~~the substantial~~ a part of the electric power steering apparatus according to the first preferred embodiment of the present invention.

36 FIG. 3 is a sectional view along the line X-X in FIG. 2.

37 FIG. 4A is an ~~explaining~~ explanatory view of the model of the beam, both ends ~~part~~ of which are held without play, and the bending moment applied to the beam.

38 FIG. 4B is an ~~explaining~~ explanatory view of the model of the beam, both ends ~~part~~ of which are held with play, and the bending moment applied to the beam.

39 FIG. ~~2~~ 5 is a ~~plan~~ plane view of ~~the substantial~~ a part of the electric power steering apparatus according to the second preferred embodiment of the present invention.

40 FIG. 6 is a ~~plan~~ plane view of ~~the substantial~~ a part of the electric power steering apparatus according to the third preferred embodiment of the present invention.

41 FIG. ~~6~~ 7 is a sectional view along the line Y-Y in FIG. ~~2~~ 6.

42 FIG. 8 is a ~~plan exploded~~ cross-sectional view of ~~the substantial~~ a part of ~~the~~ a conventional electric power steering system.

43 DESCRIPTION OF THE PREFERRED EMBODIMENT

44 First Preferred Embodiment

45 The preferred embodiments of the present invention will now be described by referring to the attached drawings. FIG. 1 is a block diagram showing the whole of the electric power steering apparatus according to the first preferred embodiment of the present invention. FIG. 2 is a ~~plan~~ plane view of the principal part of the electric power steering apparatus according to the first preferred embodiment of the present invention. FIG. 3 is a sectional view along the line X-X in FIG. 2.

46 As shown in FIG. 1, an electric power steering apparatus 1 according to the present invention has a steering wheel 2. The steering wheel 2 is connected to a pinion shaft 4 through a steering shaft 3. A torque sensor 5 and a torque transmitter 6 are ~~attached~~ provided to the pinion shaft 4. The torque sensor 5 detects the steering torque ~~add~~ to be added to the steering system (that is, to the steering shaft 3). The torque transmitter 6 is ~~an assistor, and~~ connected to an electric motor 7, ~~which adds the assists~~ and transmits an assistant steering force generated by the electric motor 7 to the steering system.

47 A pinion 4A, arranged at the bottom part of the pinion shaft 4, is engaged with a gear rack 8A provided on a rack shaft 8. In this construction, the rotation of the pinion shaft 4 is ~~converted~~ changed into ~~the displacement~~ a movement in ~~the~~ a longitudinal direction with respect to the rack shaft 8~~, and then a~~. Thus, steered ~~wheel 9 and~~ wheels 9 are steered in compliance with the rotation of the pinion shaft. The torque sensor 5 is

connected to a control unit 10, and outputs the toque signal T to the control unit 10. The control unit 10 computes ~~the assist~~ an assistant steering force using ~~at least~~ the torque signal T ~~outputted form~~ from the torque sensor 5, and outputs ~~the~~ an electric motor control signal ~~VO~~ V_0 to the electric motor 7~~, and thus~~. Thus, the rotation of the electric motor 7 is controlled by the motor control signal V_0.

48 As shown in FIG. 2 and FIG. 3, the torque transmitter 6 has a worm wheel 11, which is ~~fixed~~ coaxially provided to the pinion shaft 4 ~~so that it might be in the coaxial location with respect to the pinion shaft4. A worm shaft 12 is joined to the rotation shaft of the electric motor 7 through the coupling and the like. A~~. The worm wheel 11 is engaged with a worm ~~gears~~ gear 12A provided on the worm shaft 12 ~~is engaged with the worm wheel 11~~. That is, the pinion shaft 4 is connected to the electric motor 7 through the worm wheel 11 and worm gear 12A.

49 When the ~~worm shaft 12 is rotated by the actuation of the~~ electric motor 7~~,~~ is operated and the worm shaft 12 is rotated, a rotation torque (assistant steering force) generated by the electric motor 7 is transferred to the worm wheel 11 ~~engaged with~~ through the worm ~~gears~~ gear 12A ~~is rotated~~, and thus the pinion shaft 4 is rotated ~~along with the rotation of the worm wheel 11 through the mechanism such as a planetary gear and the like~~ in compliance with the rotation of the worm shaft. ~~The assist steering force (steering force) brought by the electric motor 7 is transmitted to the pinion shaft 4, and then transmitted to~~ Thereby, the steering force of the steering shaft 3 ~~through the pinion shaft 4~~ is enhanced.

50 ~~One~~ The first end ~~part~~ 12B of the worm shaft 12 is ~~held~~ supported by a first supporting unit including a first ball bearing 14A and a second ball bearing 14B, which are ~~arranged in the adjoining location~~ arrayed along the longitudinal direction of the worm shaft 12, ~~on allowing the~~ so as to allow rotation of the worm shaft 12.

51 ~~The~~ These ball bearings 14A and 14B ~~are a holding means, which holds~~ support the ~~one~~ first end ~~part~~ 12B of the worm shaft 12 with sufficient flexural rigidity. In other words, ~~the holding means restricts~~ ball bearings 14A and 14B restrict the flexure of the worm shaft 12, which also may be referred to as radial run-out of the worm shaft 12.

52 ~~Another~~ The second end ~~part~~ 12C of the worm shaft 12~~, furthermore,~~ is ~~held~~ supported by a second supporting unit including a first ball bearing 15A and a second ball bearing 15B, which are ~~arranged in the adjoining location~~ arrayed along the longitudinal direction of the worm shaft 12, ~~on allowing the~~ so as to allow rotation of the worm shaft 12.

53 ~~The ball~~ Ball bearing 15A and 15B ~~are also a holding means, which holds~~ support the ~~one~~ second end ~~part~~ 12C of the worm shaft 12 with sufficient flexural rigidity. In other words, the holding means restricts the flexure of the worm shaft 12.

54 ~~The~~ As shown, the location interval L1 between ~~the~~ ball ~~bearing~~ bearings 14A and 14B and the location interval L2 between ~~the~~ ball ~~bearing~~ bearings 15A and 15B are the same. The location interval L1 and the location interval L2 ~~are established~~ may be made large, as long as ~~possible so that it can~~ the bearings still restrict the flexure of the worm shaft 12 efficiently, so as to prevent radial run-out of the worm shaft.

55 The ~~explanation about the~~ function and the operation of the electric power steering apparatus having the above-described construction ~~will be carried out~~ is explained as follows.

56 When the ~~driver operates the~~ steering wheel 2 ~~shown in FIG 1~~ is turned by a driver, the torque sensor 5 detects the steering torque and generates the torque signal T. The ~~steering torque detected by the torque sensor 5 is output~~ torque signal T is supplied to the control unit 10 ~~as a torque signal T~~.

57 ~~In the~~ The control unit 10~~, the assist~~ computes an assistant steering force~~, which is brought by the electric motor 7 and add~~ to be applied to the steering system~~, is~~

~~computed using at least the steering torque represented by~~ based on the torque signal T ~~on considering the factors such as~~ and in consideration of the traveling speed of the vehicle and the ~~steering~~ turning angle of the steering wheel. ~~Based on this computed assist steering force, the electric~~ Then the control unit 10 outputs the motor control signal ~~Vo is output to the electric motor 7 from the control unit 10~~ V_0, which is generated based on the computed assistant steering force.

58 ~~The~~ As shown in FIG. 2, the electric motor 7 is ~~driven by~~ activated in compliance with the ~~electric~~ motor control signal Vo, and rotates the worm shaft 12 ~~of shown in FIG. 2~~. ~~One~~ Since in this instance the first end ~~part~~ 12B of the worm shaft 12 is ~~held~~ supported by ~~the~~ ball ~~bearing~~ bearings 14A and 14B while the worm shaft 12 is rotating. ~~Another~~, and the second end ~~part~~ 12C of the worm shaft 12 is also ~~held~~ supported by ~~the~~ ball ~~bearing~~ bearings 15A and 15B. ~~Thus, both end parts of~~, the worm shaft 12 ~~is in the held condition by holding both end part 12B and 12C of the worm shaft 12 on allowing the rotation of the worm shaft~~ may be rotated without radial run-out.

59 ~~The~~ An explanation ~~about~~ of the flexural resistance of the worm shaft 12 ~~will be carried out on~~, considering the worm shaft 12 as a beam, is now provided.

60 FIG. 4A is an ~~explaining~~ explanatory view of the bending moment ~~in the case that the~~ applied to a beam H that is generated when a force P is applied from above to the center ~~in the longitudinal direction~~ of a beam in a longitudinal direction. ~~from the upper direction, wherein~~ Here, both ~~end parts~~ ends of the beam are rigidly held without play ~~(play means it has a loose fit)~~.

61 ~~FIG. 4A is an explaining view of the bending moment in case that the force P is applied to the center in the longitudinal direction of a beam from the upper direction, wherein both end parts of the beam are held with play (play means it has a loose fit).~~

62 As shown in FIG. 4A, ~~in the case of the beam H, which has a length l and both~~

~~end parts HA and HB of which are rigidly held without play,~~ the bending moment ~~add thereto is Pl/8~~ added to the beam H, which has a length *l*, with both ends HA and HB held rigidly without play, is P*l*/8.

63 As shown in FIG. 4B, ~~in the case of the beam H, which has a length l and both end parts HA and HB of which are held with play,~~ the bending moment ~~add thereto is Pl/4~~ added to the beam H, which has a length *l*, with both ends HA and HB held rigidly with play, is P*l*/4.

64 The bending moment applied to the beam H~~,~~ with both ~~end parts~~ ends HA and HB ~~of the which are rigidly held~~ supported without play~~, becomes~~ is one half ~~in the case that~~ the bending moment when both ~~end parts~~ ends HA and HB of the beam H are supported with play. Thus, when both end parts HA and HB of the beam H are rigidly held without play, the bending moment ~~might~~ may be made smaller than ~~the case where~~ when both ~~end parts~~ ends HA and HB are supported with play.

65 ~~When the force P is applied to the center in the longitudinal direction~~ The maximum amount of distortion of the beam H ~~from the upper direction~~ (hereinafter "maximum distortion", or δ_{max}), , when a force P is applied from above to the center of the beam H in the longitudinal direction, wherein both ~~end parts of which~~ ends HA and HB are rigidly held without play, ~~the maximum flexural amount (δ max) of the beam H~~ is formulated as formula (1).

66 ~~$\delta max = Pl^3/192EI_z$ (1)~~ $\delta_{max} = Pl^3/192EI_z$ (1)

67 P: the force added to the beam H

68 ~~l~~ *l*: the length of the beam H

69 E: Young's modulus

70 I_z: geometrical moment of inertia

71 ~~On the contrarily~~ However, when the force P is applied from above to the center of the beam in the longitudinal direction ~~of the beam H from the upper direction~~,

wherein both ~~end parts of which~~ ends HA and HB are held with play, the maximum flexural amount ~~(δ max)~~ δ_{max} of the beam H is formulated as formula (2).

72 ~~δ max = Pl^3/48EI$_z$ (2)~~ $\delta_{max} = Pl^3/48EI_z$ (2)

73 P: the force applied to the beam H

74 ~~l~~ l: the length of the beam H

75 E: Young's modulus

76 I_z: geometrical moment of inertia

77 ~~Therefore, the flexural~~ Thus, the amount of distortion of the beam H~~, wherein~~ with both ~~end parts are rigidly held~~ ends supported without play ~~becomes to~~ one fourth ~~with respect to~~ as in the case where both ~~end parts~~ ends are ~~held~~ supported with play. ~~As described above, when~~ Thus, with both ~~end parts~~ ends HA and HB of the beam H ~~are rigidly held~~ supported without play, the ~~flexural~~ amount of distortion of the beam H can be made smaller than ~~that of the beam H,~~ with both ~~end parts of which are held~~ ends supported with play. ~~The beam with~~ Thus, sufficient flexural rigidity and ~~with~~ high flexure resistance can be ~~supplied~~ achieved when both ~~end parts~~ ends of the beam are ~~held~~ supported without play.

78 ~~Therefor, when~~ Therefore, if both end parts of the beam H are ~~rigidly held~~ supported without play, the ~~holding of the~~ beam ~~member can be carried out with~~ may be provided with sufficient rigidity ~~than the case where the both end parts are supported with play, and thus the maximum flexural amount~~ and the distortion of the beam H can be ~~smaller~~ small.

79 ~~As for the electric~~ In the first preferred embodiment of the power steering apparatus 1 ~~according to the present preferred embodiment~~, the worm shaft 12 is ~~rigidly held~~ supported by ~~the~~ ball ~~bearing~~ bearings 14A, 14B, 15A and 15B without play. ~~Since the same reason as described in the case of beam H can be applicable~~ Thus, the

worm shaft 12 according to the present invention can be ~~held with sufficient flexural~~ supported with superior rigidity as compared to ~~the~~ a conventional holding manner.

80 ~~When~~ In the present embodiment, therefore, when the electric motor 7 is operated and the force P is applied to the center in the longitudinal direction of the worm shaft 12 as a result ~~of the actuation of the electric motor 7~~ thereof, ~~therefore,~~ the bending moment ~~becomes to~~ is one half what it would be if the ends of the worm shaft 12 were not supported, and the maximum ~~bending amount becomes~~ distortion of the worm shaft 12 is one fourth what it otherwise would be. Thus, ~~the flexure~~ excessive distortion of the worm shaft 12 is ~~efficiently~~ reliably prevented.

81 ~~Then, the occurrence of the mismatch, which is~~ Therefore, defects caused in conventional power steering systems by ~~the flexure~~ distortion of the worm shaft ~~at the time of~~ when the steering wheel is ~~turning~~ turned back in the reverse direction are avoided in the present embodiment. ~~, and~~ Consequently, the ~~aggravation of the steering responsibility in the electric power steering apparatus 1 are sufficiently prevented. Thus, the transmission of the assist~~ assistant steering force ~~brought~~ generated by the electric motor 7 is reliably transferred to the steering shaft 3 ~~can be achieved~~.

82 In the present embodiment, ~~furthermore, due to~~ when the weight of the electric motor 7 is high, the ~~difference between the flexural rigidity~~ distortion at ~~one~~ the first end ~~part~~ 12B of the worm shaft 12 ~~and~~ may differ from that at the ~~another~~ second end ~~part~~ 12C ~~of the worm shaft 12 may be arisen~~.

83 ~~When~~ In this case, if the worm shaft 12 is firmly connected to the rotation axis of the electric motor 7 ~~and the worm shaft 12 are joined firmly, for example~~, the ~~flexural rigidity~~ distortion at the ~~one~~ first end ~~part~~ 12B of the worm shaft 12 is ~~higher~~ lower than ~~another~~ at the second end ~~part~~ 12C ~~of the worm shaft 12 (flexural angle becomes smaller)~~. In this case, it is preferable ~~If the rotation axis of the electric motor 7 and the worm shaft 12 are joined firmly, it is acceptable~~ that the location interval L2 between

the ball ~~bearing~~ bearings 15A and 15B~~, which support another end part 12c of the worm shaft 12,~~ is ~~established~~ made to be wider than the location interval L1 between ball ~~bearing~~ bearings 14A and 14B, in order to compensate for the rigidity at first end 12B being higher than at the second end 12C.

84 ~~To be more precise, the flexural rigidity of another end part 12c side can be stronger than that of one end part 12B side, by establishing the interval between the ball bearing 15A and 15B wider than that of between the ball bearing 14A and 14B. Therefore~~ Thereby, since ~~one~~ each end ~~part~~ 12B and ~~another end part~~ 12C ~~are rigidly held with the~~ is supported with uniform flexural rigidity ~~depending on the strength of the connecting part between the rotation axis of the electric motor 7 and the worm shaft 12, the prevention of the flexure~~ , radial run-out of the worm shaft 12 can be ~~achieved more certainly~~ reliably avoided.

85 Second Preferred Embodiment

86 The second preferred embodiment according to the present invention ~~will be~~ is now described. Fig. 5 is a ~~plan sectional~~ plane view showing a substantial part of the ~~electric~~ power steering apparatus according to the second preferred embodiment of the present invention.

87 In ~~an electric~~ a power steering apparatus 20 according to the ~~present~~ second preferred embodiment, only the construction of the torque transmitter ~~is differing~~ differs from ~~the electric power steering apparatus 1~~ that of the first preferred embodiment. ~~Thus, in the~~ The following explanation~~, the explanation is mainly carried out about the different components~~ mainly addresses the construction of the torque transmitter, and ~~the same~~ components that are the same as ~~that of~~ as those already explained in the first preferred embodiment ~~is emitted and indicates as~~ are indicated by the same symbol.

88 As shown in FIG. 5, ~~a~~ the torque transmitter 21 ~~according to the present second preferred embodiment of the electric power steering apparatus 20,~~ has a worm wheel 11 ~~fixed to~~ , which is coaxially provided on the pinion shaft 4 ~~so that it might be in the coaxial location with respect to the pinion shaft 4~~.

89 ~~A~~ The worm wheel 11 is engaged with a worm gear ~~12 is joined to the electric motor 7. The worm gears~~ 12A provided ~~to~~ on the worm shaft 12, which is ~~engaged with the worm wheel 11~~ connected to an electric motor 7.

90 When the worm shaft 12 is rotated ~~by the actuation~~ in compliance with the rotation of the electric motor 7, the worm wheel 11 engaged with the worm ~~gears~~ gear 12A is rotated, and ~~then~~ the pinion shaft 4 thus is rotated along with ~~the rotation of~~ the worm wheel 11. ~~The assist~~ Thereby, the assistant steering force ~~brought by the electric motor 7 is transmitted~~ (rotation torque) is transmitted to the pinion shaft 4. ~~These compositions are same as that of disclosed in the first preferred embodiment.~~

91 ~~One~~ In the second embodiment, the first end ~~part~~ 12B of the worm shaft 12 is ~~held~~ supported by ~~the~~ ball ~~bearing~~ bearings 14A and 14B which are ~~arranged in the adjoining location along~~ arrayed along the longitudinal direction of the worm shaft 12, so as to permit the worm shaft to rotate.

92 On the other hand, ~~another~~ the second end ~~part~~ 12C of the worm shaft 12 is ~~held~~ supported by a needle bearing 22 ~~on allowing the rotation around the axis~~ so as to allow the worm shaft 12 to rotate. ~~The electric~~ In the second preferred embodiment of the power steering apparatus 20 ~~according to the present preferred embodiment~~ , the provision of the needle bearing 22 differs ~~in that the another end part 12C of the worm shaft 12 is supported without play on allowing the rotation~~ differs from the first preferred embodiment.

93 ~~As for the worm shaft 12 in~~ In the ~~electric~~ power steering apparatus 20 ~~according to the present preferred embodiment~~, ~~one~~ the first end ~~part~~ 12B of the worm

shaft 12 is ~~held~~ supported without play by ~~the two of~~ ball bearings 14A and 14B, and ~~another~~ the second end ~~part~~ 12C of the worm shaft 12 is ~~held~~ supported without play by the needle bearing 22.

94 As ~~for~~ can be seen from FIG. 5, the needle bearing 22~~, since needle rollers (located at inner side and outer side in figure) are contacting with~~ is provided at both sides of the worm shaft 12 so that the needle bearing 22 is located along the longitudinal direction of the worm shaft 12. Thus, the contact area between the needle bearing 22 and the worm shaft 12 becomes wide ~~range of~~ as compared to the contact area between the worm shaft 12 ~~is held by the needle roller~~ and the ball bearings 14A and 14B.

95 ~~Thus, flexural resistance in the diameter direction at the another~~ Thereby, since the bearing capacity at the second end ~~part~~ 12C of the worm shaft 12 ~~where is supported by the needle bearing 22 is~~ becomes higher than ~~one~~ at the first end ~~part~~ 12B, ~~. Therefore, since another end part 12C is held by the needle bearing 22, the flexural rigidity at the another~~ end ~~part~~ 12C of the worm gear 12 is ~~also higher~~ supported with superior rigidity than ~~the one~~ end ~~part~~ 12B ~~where the worm gear 12 is held by the ball bearing 14A and 14B~~.

96 ~~The flexural~~ However, the rigidity at ~~one end part~~ both ends 12B and ~~another end part~~ 12C ~~of~~ can be made uniform if the worm shaft 12 ~~can be uniform by holding~~ the ~~another ends part 12C using the needle bearing 22, which gives the superior flexural resistance, even if the rigidity at the one ends part 12B becomes high as a result of the firmly connection between the rotating shaft of~~ is connected to the electric motor 7 ~~and the worm shaft 12~~ so as to also make rigidity at the first end 12B high, as described above.

97 ~~The occurrence of the flexure~~ Thereby, distortion of the worm shaft ~~is thus~~ may be prevented. In addition, ~~and also the occurrence of~~ the feeling gap, that is, the difference between ~~in the case~~ the impression when the steering wheel is turned ~~back~~ in

the anticlockwise direction and ~~in the case~~ the impression when the steering wheel is turned ~~back~~ in the clockwise direction, can be decreased. ~~Thus, not only the prevention of the aggravation of steering feeling but also the certain transmission of the steering force brought by the electric motor 7 to the pinion shaft 3 are achieved~~. Since the assistant steering force is reliably transferred to the steering shaft 3, the operational ability of the steering wheel is not impaired.

98 Third Preferred Embodiment

99 The third preferred embodiment of the present invention ~~will be~~ is now explained. FIG. 6 is a ~~plan sectional~~ plane view of ~~the~~ a substantial part of the ~~electric~~ power ~~assist type~~ steering apparatus according to the third preferred embodiment of the present invention. FIG. 7 is sectional view along the line Y – Y in FIG 6.

100 In the ~~electric~~ power steering apparatus 30 according to the ~~present~~ third preferred ~~invention~~ embodiment, only the construction of the torque transmitter ~~is differing~~ differs from the ~~electric~~ first preferred embodiment of the power steering apparatus 1. Thus, in the following explanation, the explanation is mainly ~~carried out about~~ addressed to the different components, and discussion regarding ~~the same~~ components that are the same as ~~that of~~ those explained in the first embodiment is ~~emitted and indicates as~~ omitted, those components being identified using the same symbol as in the first preferred embodiment.

101 As shown in FIG. 6, a torque transmitter ~~21~~ 31 according to the ~~present second~~ third preferred embodiment of the electric power steering apparatus 30~~,~~ has a worm wheel 11 ~~fixed to~~ , which is coaxially provided on the pinion shaft 4 ~~so that it might be in the coaxial condition with the pinion shaft 4~~.

102 The worm ~~gear 12~~ wheel 11 is ~~joined to the electric motor 7, and~~ engaged with a worm gear 12A provided ~~thereto is engaged with~~ on the worm ~~wheel 11~~ shaft 12, which is connected to an electric motor 7.

103 When the worm shaft 12 is rotated by ~~the actuation of~~ the electric motor 7, the worm wheel 11 engaged with the worm gear 12A is rotated, and ~~then~~ the pinion shaft 4 is rotated ~~along~~ together with the worm wheel 11. ~~The assist~~ Thereby, the assistant steering force ~~brought by the electric motor 7~~ (rotation torque) is transmitted to the pinion ~~shaft4~~ shaft 4. ~~These compositions are same as that of disclosed in the first and second preferred embodiment.~~

104 ~~One~~ In the third preferred embodiment, the first end ~~part~~ 12B of the worm shaft 12 is ~~held~~ supported by a ball bearing 32 ~~in the condition the~~ so as to permit rotation of the worm shaft 12 ~~might be allowed~~. ~~Another~~ The second end ~~part~~ 12C is ~~also held~~ supported by a ball bearing 33 ~~in the condition where the~~ so as to permit rotation of the worm shaft 12 ~~might be allowed~~.

105 A ~~central holding means~~ distortion prevention unit 35 is ~~arranged~~ provided at the ~~almost central part~~ middle in the longitudinal direction of the worm shaft 12. The ~~central holding means~~ distortion prevention unit 35 is positioned ~~so that~~ on the opposite side of the worm shaft 12 with respect to the worm wheel 11. That is, the worm shaft 12 ~~might be sandwiched~~ is located between the worm wheel 11 and the ~~central holding means~~ distortion prevention unit 35~~, and~~. The distortion prevention unit has ~~a urging means~~ an engagement assistor 34 ~~which crowds~~ which pushes the worm shaft 12 toward the ~~direction of~~ pinion shaft 4 so that the worm gear 12A is engaged with the worm wheel 11. ~~According to this urging means 34, the worm shaft 12 is pressed toward the worm wheel 11 from the opposite direction side with respect to the engaging part where the worm gear 12A and worm wheel 11 are engaged together. This urging means 34 is arranged for pressing the worm shaft 12 to the engaging part of the worm wheel 11, and~~

The distortion prevention unit 35 is composed of a spring 36, an upper roll 37, a lower roll 38, and a roller holder 39 (see FIG.7).

106 As shown in FIG. 7, ~~the urging means 34 has~~ the upper roll 37 and the lower roll 38 ~~which are arranged at the opposite side with respect to the engaging part where the worm wheel 11 and the worm gear 12A of the worm shaft 12 are engaged together. The urging means 34 also has a~~ are rotatably supported by the roller holder 39~~, which rotatably supports the~~. The upper roll ~~38~~ 37 and the lower roll ~~39, and~~ 38 are pushed toward the worm shaft 12 by the spring 36, which press the roller holder 39 towards the worm shaft 12 urgently. The upper roll 37 and the lower roll 38 are fit and com in contact with the worm gear 12A~~, respectively, and transmit urgent force brought by the spring 36 to the worm gear 12A. The rotation shafts of the upper roll 37 and the lower roll 38 are supported by the roller folder 39 and thus the~~. Thus the worm gear 12A is reliably pushed toward the worm wheel 11. In the third preferred embodiment, the rotation axes of the upper roll 37 and the lower roll 38 are established so as to become parallel with respect to the worm shaft 12, and are established so as not to move in an up-and-down direction That is, movement of the upper roll 37 and lower roll 38 in the ~~ups and downs directions thereof is restricted~~ up-and-down direction is prevented.

107 In the ~~electric~~ power steering apparatus 30 ~~according to the present preferred embodiment, about the center part in the longitudinal direction of~~, the worm shaft 12 is supported by the ~~center holding means~~ distortion prevention unit 35 at the middle in the longitudinal direction of the worm shaft 12. ~~The flexural degree~~ This is because the amount of distortion of the worm shaft 12~~, conventionally,~~ tends to be ~~maximum~~ highest at the ~~central part~~ middle in the longitudinal direction of the worm shaft 12. ~~As for the present~~ In the third preferred embodiment, since the middle in the worm shaft 12 is ~~supported~~ pushed by the ~~center holding means~~ distortion prevention unit 35, ~~the occurrence of the flexure~~ distortion of the worm shaft 12 is ~~efficiently prevented~~

reliably avoided. As a result ~~of this prevention~~, the ~~aggravation arose at the time of turning back of the steering is prevented, and thus the prevention of the aggravation~~ variation of the steering feeling may be avoided, and the ~~certain transmission of the~~ assistant steering force generated by the electric motor 7 may be reliably transmitted to the pinion shaft ~~can be achieved~~ 4. In other words, the operational ability of the steering wheel is not impaired.

108 In the present invention, ~~the central part between one end part and the another end part~~ since the middle in the longitudinal direction of the worm shaft 12 is ~~supported, the scattering in the flexural resistance in the longitudinal direction~~ pushed by the distortion prevention unit 35, distortion of the worm shaft 12 can be ~~smaller~~ avoided. ~~Thus, the gaps in the steering feeling depending on the turning direction of the steering can be smaller.~~ Thus, the operational ability of the steering wheel is not impaired.

109 ~~As for~~ In the ~~present invention~~ third preferred embodiment, furthermore, since the ~~center holding means~~ distortion prevention unit 35 has the ~~urging means~~ engagement assistor 34, so that the ~~urgent~~ force brought by the spring 36 is transmitted to the worm shaft 12 through the upper roll 37 and the lower roll 38. ~~Accordingly~~, the clearance between the worm gear 12A and the worm wheel 11 is maintained. This may be true ~~within the predetermined clearance~~ even if the clearance~~, which exceeds a predetermined clearance value, come close to arising~~ occurs as a result of ~~the occurrence of~~ a slight inherent flexure of the worm ~~gear~~ shaft 12.

110 ~~The~~ In the third preferred embodiment, the worm gear 12A and the worm wheel 11 are ~~certainly~~ reliably engaged ~~together by the center holding means 35, the unpleasant~~, so that backlash between the worm gear 12A and the worm wheel 11 ~~thus can~~ may be ~~prevented~~ avoided. ~~Then~~ Thus, ~~the transmission of~~ the ~~assist~~ assistant steering force ~~brought~~ generated by the electric motor 7 may be reliably transferred to the worm wheel 11 through the worm shaft 12 ~~can be achieved certainly~~.

111 ~~Since~~ In the third preferred embodiment, since the ~~urgent force brought by the spring 36 is transmitted to the worm shaft 12A through the~~ upper roll 37 and the lower roll 38 ~~which~~ are ~~being~~ rotatable, the rotation of the worm shaft 12 ~~is carried out without any restriction~~ is not prevented by the upper roll 37 and lower roll 38 when the worm shaft 12 is pushed toward the worm wheel 11 by the distortion prevention unit 35.

112 ~~The displacement in the ups-and-downs directions of~~ In the third preferred embodiment, additionally, the upper roll 37 and the lower roll 38~~, which are applied to the worm shaft 12,~~ are restricted~~, furthermore, the displacement in the ups-and-downs directions~~ from moving in the up-and-down direction. Thus, since the worm shaft 12 is prevented from moving in the up-and-down direction by the upper roll 37 and the lower roll 38, distortion of the worm ~~gear~~ shaft 12 in the up-and-down direction is also prevented.

113 ~~According to this prevention, the flexure in the ups-and-downs directions of the worm gear 12 is also prevented. Thus, the aggravation of the steering feeling is prevented, and also~~ Thus, the assistant steering force~~, which is brought by the electric motor,~~ is ~~certainly transmitted to the pinion shaft~~ reliably transferred to the steering system. According to the supporting mechanism of the present invention, since the worm ~~gear~~ shaft 12 is supported by the upper roll 37 and lower roll 38, the supporting mechanism ~~with~~ can be made with reduced ~~unpleasant~~ friction ~~can be supplied~~.

114 In the ~~present~~ third preferred embodiment as described, both ~~end parts~~ ends of the worm ~~gear~~ shaft 12 are held by the ball bearings 32 and 32, but the ~~holding~~ supporting manner of the worm ~~gear~~ shaft 12 is not restricted to this ~~case~~. The ~~holding~~ supporting manner, for example, in which the ball bearing 33 that supports the second end of the worm ~~gear~~ shaft 12 is omitted, ~~held without the ball bearing arranged at another end part of the worm gear can be applicable~~ may be acceptable as long as the ~~flexural resistance brought by the center holding means is acceptable~~ distortion of the

worm shaft 12 is prevented by the distortion prevention unit 35.

115 In the ~~present~~ above preferred ~~embodiment~~ embodiments, ~~the explanation about the electric~~ a power steering apparatus, which assist the steering effort of the driver by adding the assist steering force brought by the electric motor in addition to the steering force brought by the driver's operation, ~~is carried out~~ is described.

116 The application of the present invention is not restricted to the above-described ~~case~~ embodiments. ~~The application to the another type~~ Other types of construction may be acceptable as long as the ~~it has a construction that the diving~~ driving force generated by the electric motor is ~~add~~ added to the pinion shaft~~, which is joined to the rack shaft and steers the steering wheel~~ through the worm wheel and the worm shaft. ~~As an~~ For example ~~of this~~, ~~the~~ a steer-by-wire mechanism, in which ~~steers~~ the steered wheel is steered only by the driving force~~, which~~ that is ~~brought~~ generated by the electric motor ~~and is controlled by the electric signal~~, and ~~the~~ a four-wheel-steering mechanism ~~and the like are considerable~~ may be considered.

117 As described above, in the present invention, the worm shaft 12 is ~~held~~ supported with sufficient flexural rigidity by ~~holding~~ supporting the worm shaft without play. According to this invention, since the ~~flexure~~ distortion of the worm shaft 12 is prevented, the ~~aggravation~~ difficulties caused by the ~~flexure~~ distortion of the worm shaft 12 ~~at the time of~~ when turning ~~back of~~ the steering in different directions is prevented. As a result of this prevention, ~~the aggravation~~ impairment of the steering ~~feeling~~ may be avoided, and ~~the certain transmission of~~ the assistant steering force~~, which is brought~~ generated by the electric motor~~,~~ can be reliably transmitted to the pinion shaft ~~can be achieved~~.

118 In the present invention, ~~one end part and another end part~~ both ends of the worm shaft are held by ~~plural of~~ ball bearings, respectively. According to this invention, the worm shaft 12 is held without play ~~on maintaining the smooth~~, so as to

permit rotation of the worm gear 12A. Since ~~the~~ ball ~~bearing which~~ bearings are general-purpose components ~~is used~~, furthermore, ~~it~~ their use can contribute to a cost reduction.

119 In the present invention, both ~~end parts~~ ends 12B and 12C of the worm shaft 12 are held with ~~the~~ uniform flexural rigidity ~~by holding the another~~ . This is accomplished by supporting the second end ~~part side, in which the~~ 12C, where the flexural rigidity is relatively low ~~a little~~, ~~by the~~ using a needle bearing. According to this invention, the ~~flexure~~ distortion of the worm shaft 12 is ~~certainly~~ reliably prevented and also the ~~occurrence of the feeling gap between in the case the steering is turned back in the anticlockwise direction and in the case the steering is turned back in the clockwise direction can be decreased the certain transmission of the~~ operational ability of the steering wheel is not impaired. The assistant steering force ~~brought~~ generated by the electric motor 7 is reliably transferred to the pinion shaft 3 ~~is achieved~~.

120 In the present invention, ~~the occurrence of the flexure of~~ distortion of the worm shaft 12 can be prevented while the worm shaft ~~is made into the rotatable condition~~ nevertheless is free to rotate. According to this invention, ~~the aggravation~~ impairment of the steering ~~feeling~~ may be avoided, and ~~the certain transmission of~~ the assistant steering force~~, which is brought~~ generated by the electric motor~~,~~ can be reliably transmitted to the pinion shaft ~~can be achieved~~.

121 In the present invention, since the worm shaft 12 is ~~pressed to the engaging part between the worm shaft and~~ pushed toward engagement with the worm wheel 11 by the ~~urgent force of the urging means with the suitable force~~ supporting units, the clearance between the worm shaft 12 and the worm wheel 11 can be maintained within ~~the~~ a predetermined ~~ranges~~ range. According to the present invention, since the occurrence of ~~the~~ backlash between the worm gear 12 and the worm wheel 11 is ~~prevented~~ avoided, the rotation of the worm shaft 12 is ~~certainly~~ reliably transmitted to the worm wheel 11.

122 In the present invention, ~~the~~ displacement of the worm shaft 12 in the ~~ups-and-downs directions of the worm shaft~~ up-and-down direction is restricted. The worm shaft 12 is ~~crowed toward the engaging part~~ pushed toward engagement with the worm wheel ~~on allowing~~ while the ~~rotation of the~~ worm shaft 12 nevertheless remains rotatable. According to the invention, since ~~the roller is~~ rollers 37 and 38 are used, ~~the unpleasant~~ friction ~~with respect to~~ the worm gear can be reduced.

123 ABSTRACT OF THE DISCLOSURE

124 ~~To provide the electric motor assist type power steering apparatus, which can prevent the aggravation of the feeling of the steering, and which can transmit the assist steering force brought by the electric motor to the steering shaft completely, by preventing the flexure of the worm shaft of the electric motor assist type power steering apparatus, preferably the pinion assist type electric power steering apparatus.~~

125 ~~To attain these object, there is provided an~~ An electric power steering apparatus ~~comprising;~~ with an electric motor ~~for adding the assist~~ generating an assistant steering force for transmission to the steering system, ~~a controller which drives said electric motor, a rack shaft which steers a steered wheel by displacing along the axial direction thereof, a pinion shaft which is engaged with said rack shaft through the rack and pinion mechanism,~~ a worm shaft ~~which is~~ rotated by the electric motor, ~~and~~ a worm gear on the worm shaft that rotates therewith, a worm wheel ~~which is engaged with~~ rotated by the worm gear, ~~said worm shaft and is integrally arranged with the~~ a pinion shaft that rotates with the worm gear, ~~one end part of the worm shaft is joined with the electric motor, and holding means, which holds one end part and another end part~~ supporting units that support both ends of the worm shaft ~~on allowing the~~ so as to allow rotation thereof, ~~is further arranged~~ and a distortion prevention unit that prevents distortion of the worm shaft.